A Smart Garment for Older Walkers

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Abstract. Walking is cited as the best form of exercise for persons over the age of 60. In this paper we outline the development and evaluation of a smart garment system that is used to monitor the wellbeing of users in addition to their overall physical activity regimes. A technological solution has been produced offering the desired functionality and is delivered in a simple user-friendly form factor. In this paper we outline the development and evaluation of a prototype as part of an iterative development cycle, with 6 participants aged between 60 and 73 years of age. The results show that technology has the potential to be accepted by older users and improve their activity regimes.

Keywords: Smart Clothing, Activity Monitoring, User-Centered Design.

1 Introduction

The ever increasing trend of population growth, coupled with falling birth rates has resulted in an ever increasing older population [1]. The majority of which exhibit a number of characteristics that are associated with the ageing process, including diminished eyesight and hearing, reduced motor responsiveness and reduced mobility [1]. Within this older population 1 in 3 suffer from 1 or more chronic conditions [2].

The World Health Organization defines health as *"a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity"* [3]. For this reason the work presented within this paper aims to promote and maintain the physical and mental fitness of older walkers in the 60-75 age range. Activities such as walking in later life are seen to significantly reduce the risk of preclinical disability and increase aerobic capacity and physical function [4].

2 Background

As the awareness of the need to maintain a certain level of physical activity increases so too does the number of personal health monitoring devices, which are readily

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available on the consumer market. Devices such as Nike+ [5] integrate an accelerometer based pedometer with the user's iDevice and estimates walking pace, distance, speed and calories burnt. Another system that monitors the activity levels of users is the Garmin Forerunner [6]. It uses GPS (Global Positioning System) to ascertain distance, speed, time and altitude. These two devices cater specifically for younger users and are not designed for use by those with age related characteristics and reduced technological capabilities and hence do not address older user's specific needs. The Design for Ageing Well project [7] aims to address the issue of the autonomy of the 60-75 year old age group using smart clothing and wearable technologies.

3 Methods

A user-centered design methodology has been adopted throughout the development of the system. In the early stages of the project, questionnaires were provided to members of the University of the Third Age [8] to elicit a set of user requirements. These questionnaires asked the users about the current technology they took with them when walking and what their views were regarding its usability. To supplement the results of these questionnaires, two user workshops were organized to obtain further detailed feedback from potential users between the ages of 60-75. Based on the feedback from the questionnaires a set of requirements was established [9], a summary of these requirements is presented in Table 1.

Table 1. Summary of user requirements elicited from questionnaires distributed to older walkers and hikers (>60 years of age), showing the desired functions of walkers only (*N=50)*.

Requirement	Walker %
Keep me in contact with my group	54.2
Tell me where my group members are	26.2
Help me navigate	54.8
Call for help should I fall	52.4
Tell me the distance covered already	54.8
Tell me where to find the nearest bus stop	23.8
Tell me where to find the nearest facilities	38.1
Monitor my health for medical reasons	16.7
Interact with my mobile phone	35.7

Once user requirements were established a technology mapping exercise was undertaken to identify the best technologies for each requirement [9]. The elicitation of user requirements and the technology mapping exercise formed the basis for the development of the prototype system. The prototype consisted of an Android Smartphone, Shimmer [10] sensor mote, Sony Ericsson LiveView [11] and an Adidas sports base layer with integrated textile electrodes. The Smartphone acted as the main hub to which peripheral devices would connect via Bluetooth and it would also store and process the data collected by the Shimmer mote. The Shimmer mote is a small wearable sensor that can, in this instance, collect ECG and accelerometer data. The LiveView device is a small micro-display that connects via Bluetooth to the Smartphone and can be used to display data or activate functions on the Smartphone itself. A simplified UI (User Interface) was developed introducing additional feedback mechanisms, such as the aforementioned micro-display. Figure 1 presents the main technology components of the prototype that is to be evaluated and the application UI.

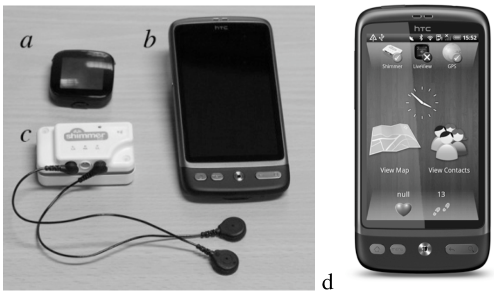

Figure 1. Prototype components used in the evaluations. a) LiveView micro-display, b) Smartphone and c) Shimmer sensor mote, d) User Interface of the Smartphone application

Using the Shimmer's ECG and accelerometer data allowed us to obtain the user's heart rate, using a Pan Tomkins algorithm [12], in addition to the levels of activity undertaken. The Smartphone's GPS capability was harnessed to record and transmit the user's GPS location to a central server that allows the viewing of relative location and distance to their friends. By using accelerometer data and the Smartphone's telephony functions a fall detector function was created. In the event of a fall the Smartphone would initialise a call, set the phone to hands-free mode and adjust the volume to the maximum.

4 Evaluation

The user evaluation consisted of 6 participants (*Male = 3, Female = 3*) between the ages of 62-73. All participants used the prototype during a short outdoor walk (15-20 minutes) in order to ascertain functional, aesthetic and UI feedback.

Male participants were asked to wear a modified Adidas based layer, 2 of the 3 female participants wore Textronics chest straps, and 1 female participant wore a custom designed bra, all of which included textile electrodes.

Following a brief overview of the system functionality, all participants were asked to undertake the walking activity in order to evaluate the system. Following evaluation of the system participants were asked to complete a post-evaluation questionnaire which considered factors ranging from the technology they currently have, to the overall usability and functionality of the developed system. It should be stressed that the evaluation did not aim to evaluate the effectiveness of the textile electrodes, step count, fall detection accuracy or the garments.

All participants, as part of the post-evaluation questionnaire, were asked if they liked using the system. Three participants answered *'Yes'*, 2 answered *'No'* and 1 answered *'Yes & No'*. From comments added by the participants, it seems most of the dissatisfaction with the system came from unreliability and slight inaccuracy of measurements i.e. Step count. Three of the 6 participants thought that the current system improved their walking experience with one remarking *'Potentially'*. This particular user clarified this statement by explaining that the system was difficult to use but if simplified they could envisage using it. A further two stated it would not improve their experience. The participants, in general, thought that the system was easy to use, with 2 participants stating the system was *'Easy'* to use and 3 stating that the system was *'OK'* to use, with one stating *'Very Difficult'*.

5 Conclusions

The aim of this evaluation was to ascertain the usability of the developed prototype with particular focus on the UI and core functionality i.e. recording a user's walk. Based on the feedback received, the system was on the whole viewed as beneficial to the participants with 3 participants believing that the technology could enhance their walking experience. Five of the 6 participants, in general, thought the system was easy to use, with answers ranging from *'Easy'* to *'OK'* to a question on usability. Feedback from this evaluation will be taken on board and the prototype will be redeveloped for further evaluation before finally going through a final development stage. Following this the entire system, including the complete clothing system, will be evaluated over a period of 4 weeks within the user's own environment.

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